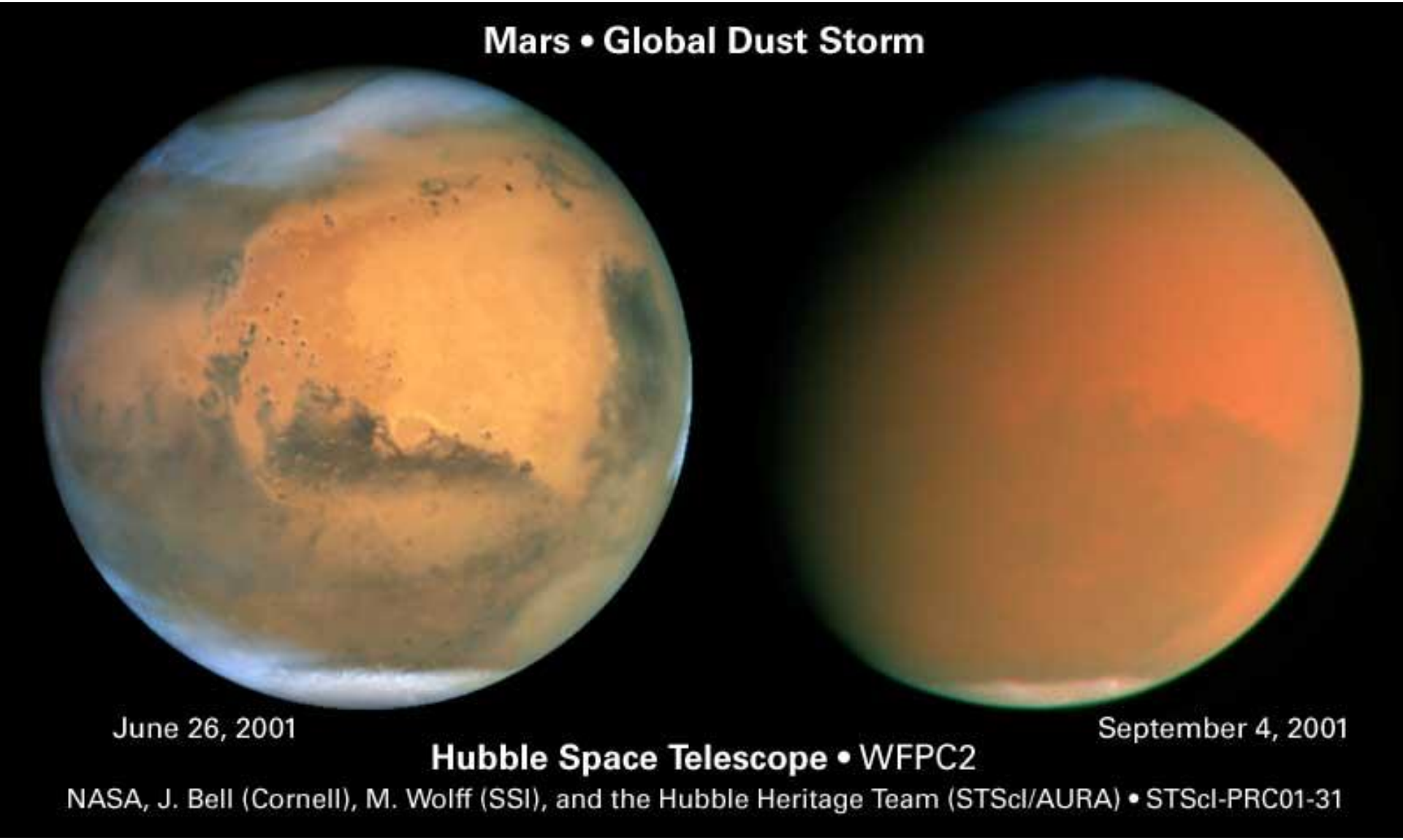
PREDICTING THE RESPONSE OF TERRESTRIAL CONTAMINATION ON MARS WITH BALLOON EXPERIMENTS IN THE EARTH'S STRATOSPHERE

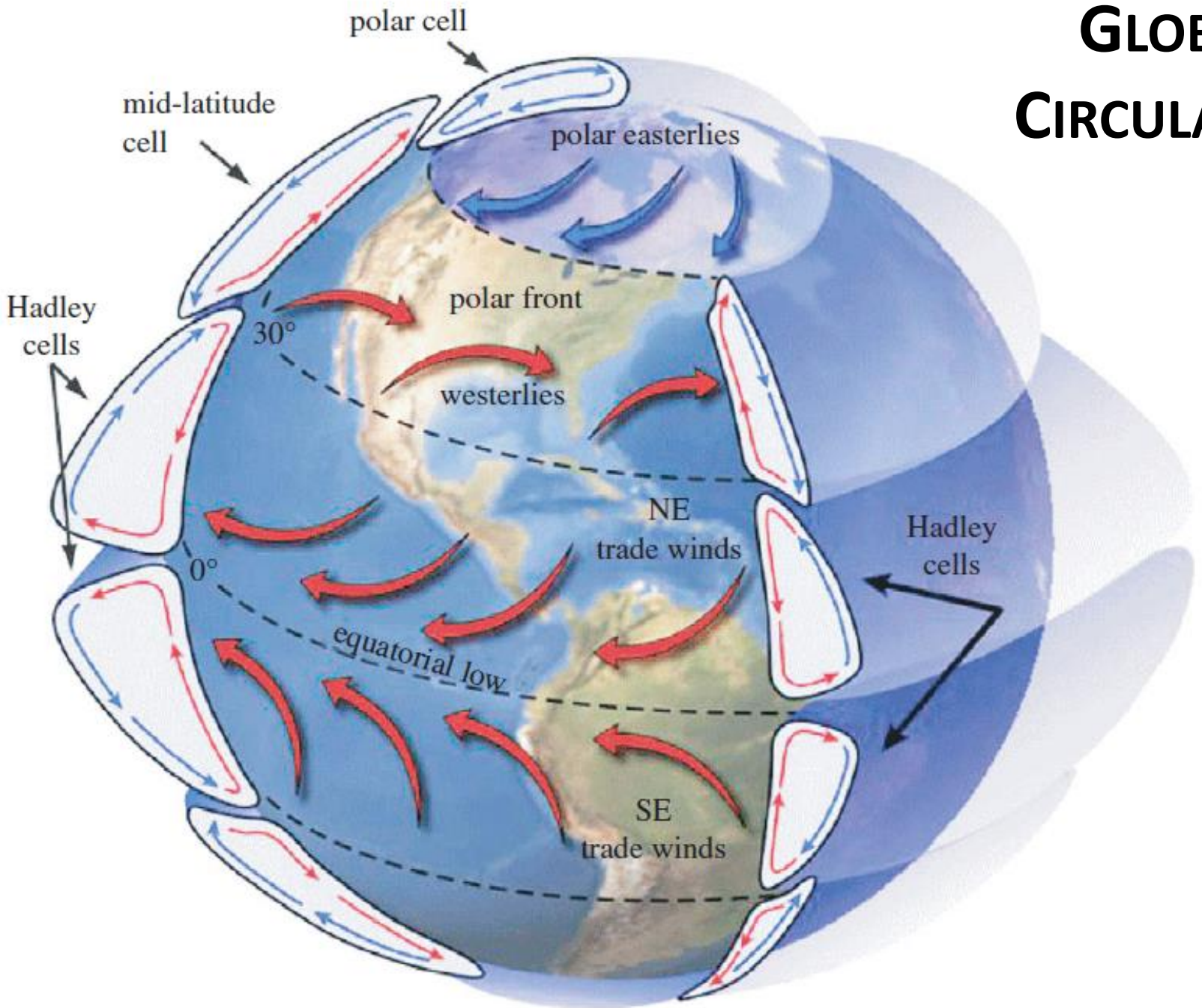
03/25/2015 – Planetary Protection Knowledge Gaps for Human Extraterrestrial Missions

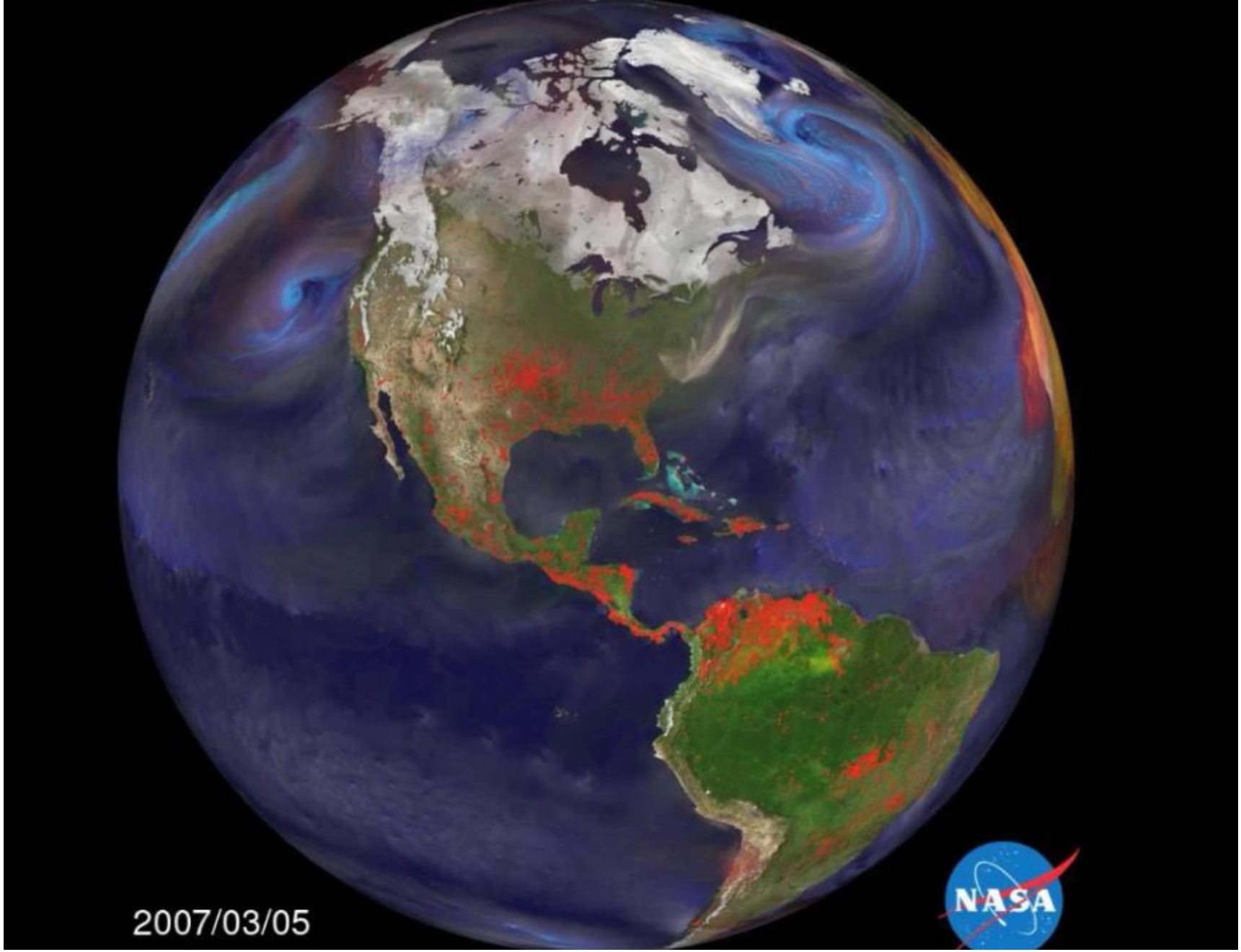
David J. Smith – NASA Ames Research Center – david.j.smith-3@nasa.gov


Mars • Global Dust Storm
June 26, 2001
September 4, 2001
Hubble Space Telescope • WFPC2
NASA, J. Bell (Cornell), M. Wolff (SSI), and the Hubble Heritage Team (STScI/AURA) • STScI-PRC01-31


We can’t predict where these will go.

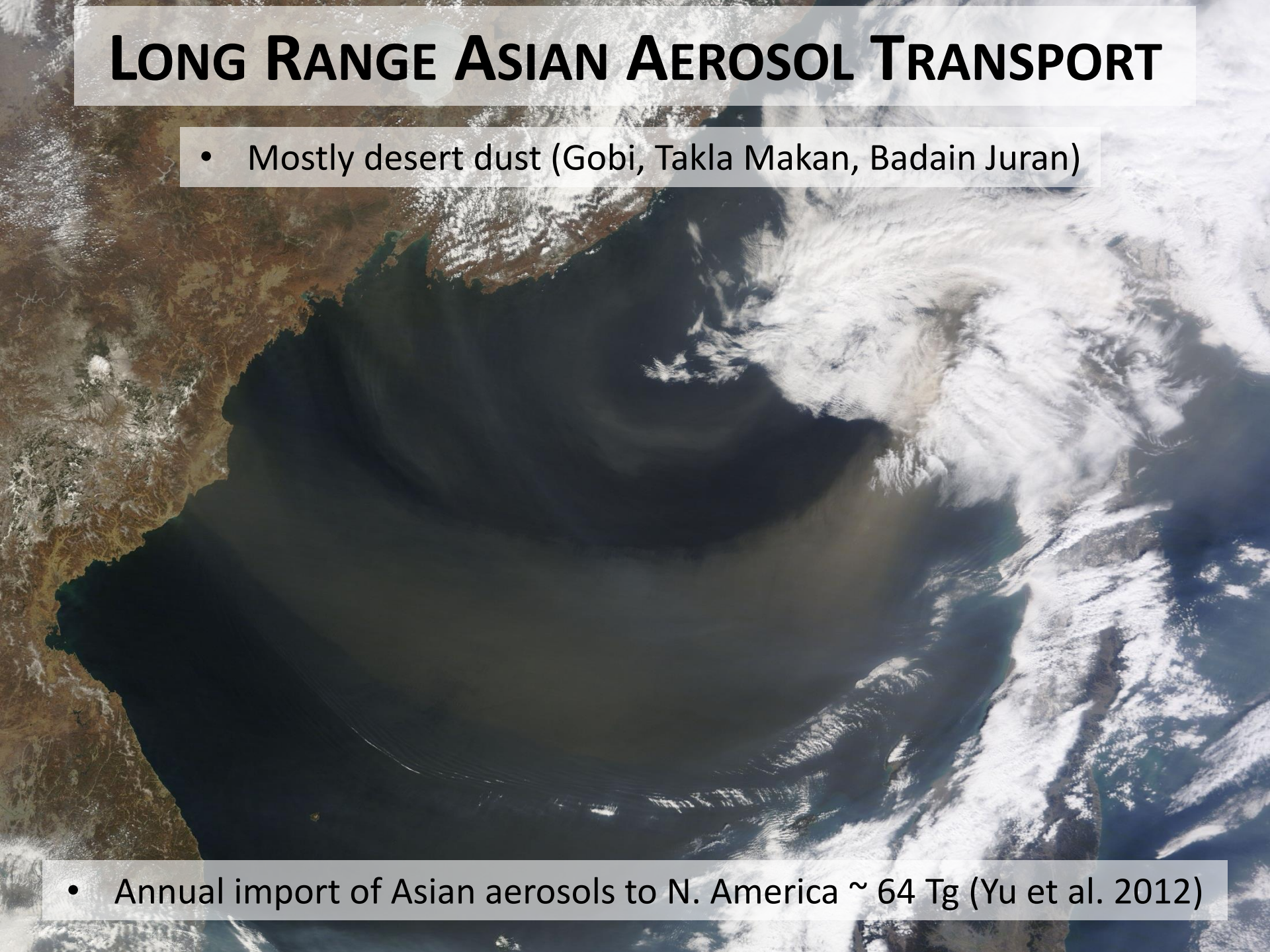
GLOBAL CIRCULATION





https://www.youtube.com/watch?v=esgHkglhG-U

Long Range Asian Aerosol Transport



- Mostly desert dust (Gobi, Takla Makan, Badain Juran)
- Annual import of Asian aerosols to N. America ~ 64 Tg (Yu et al. 2012)

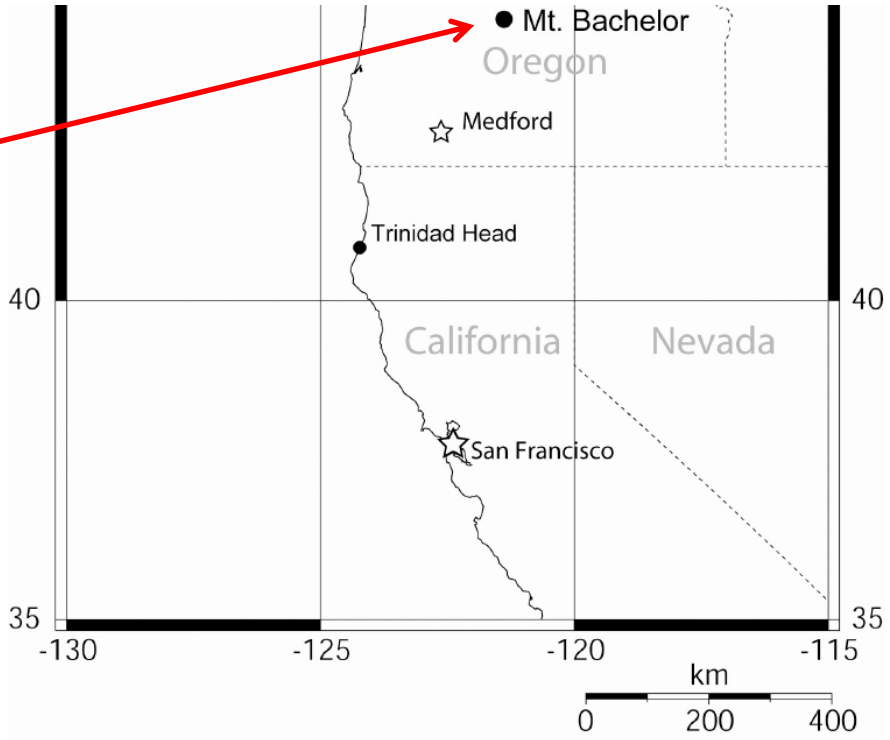
AEM Journals.ASM.org

Applied and Environmental Microbiology p. 1134–1139 February 2013 Volume 79 Number 4

Intercontinental Dispersal of Bacteria and Archaea by Transpacific Winds

David J. Smith,[a] Hilkka J. Timonen,[b] Daniel A. Jaffe,[b,c] Dale W. Griffin,[d] Michele N. Birmele,[e] Kevin D. Perry,[f] Peter D. Ward,[a] Michael S. Roberts[e]

University of Washington, Department of Biology, Seattle, Washington, USA[a]; University of Washington, Science and Technology Program, Bothell, Washington, USA[b]; University of Washington, Department of Atmospheric Sciences, Seattle, Washington, USA[c]; U.S. Geological Survey, Tallahassee, Florida, USA[d]; NASA Kennedy Space Center, ESC Team QNA, Kennedy Space Center, Florida, USA[e]; University of Utah, Department of Atmospheric Sciences, Salt Lake City, Utah, USA[f]

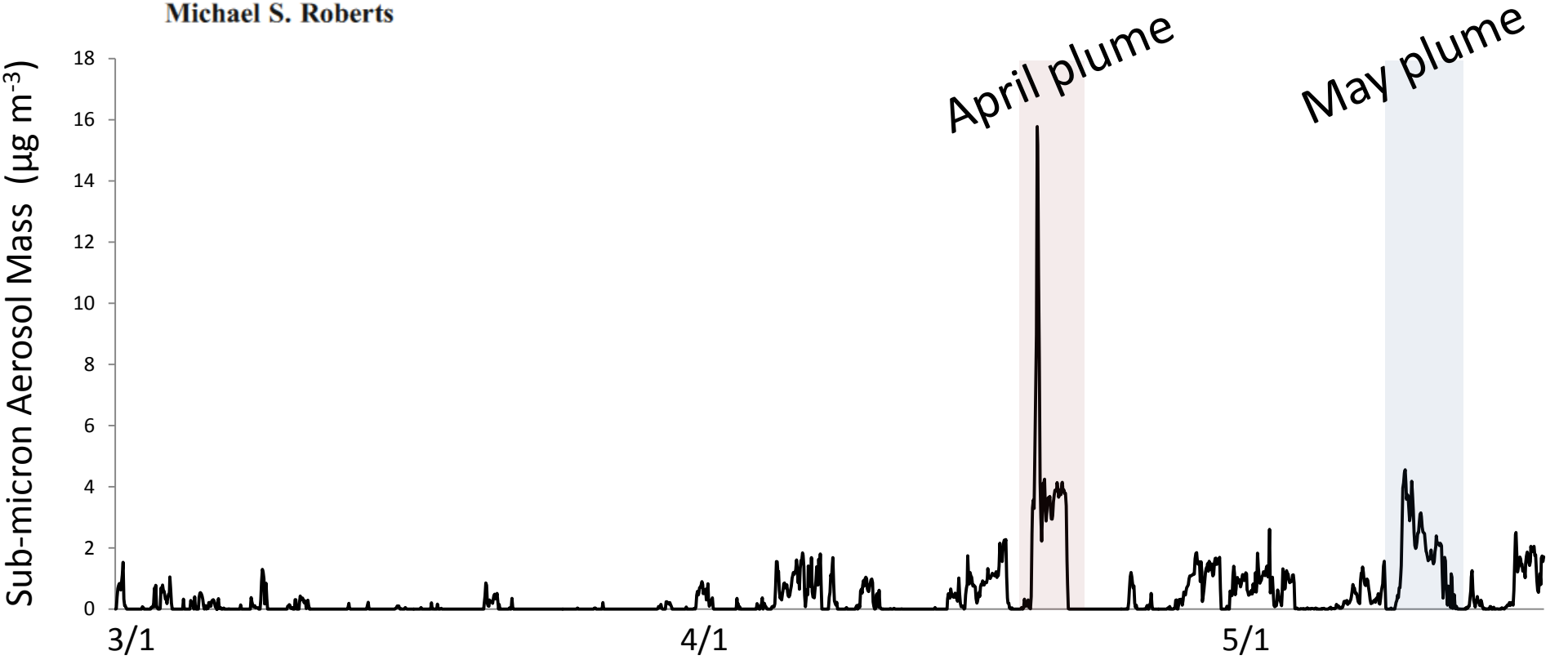


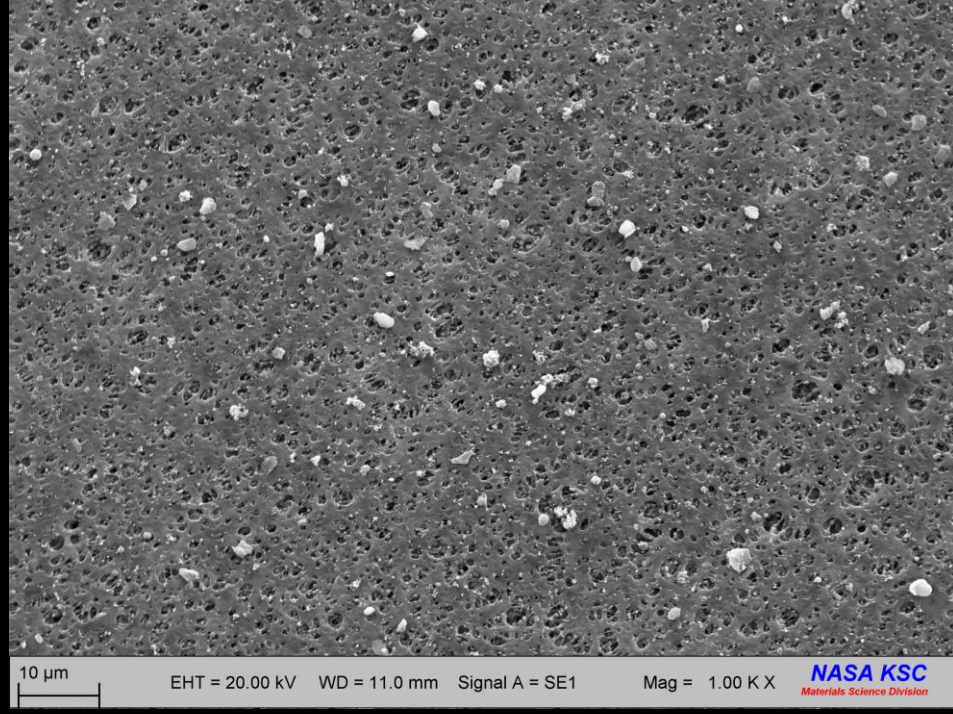
Microb Ecol (2012) 64:973–985
DOI 10.1007/s00248-012-0088-9

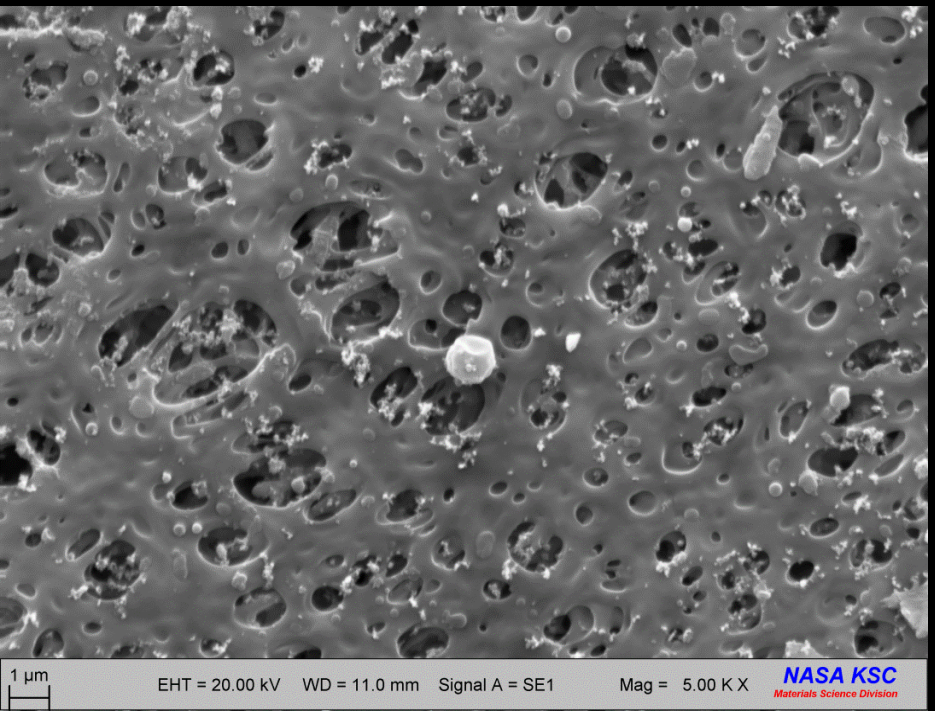
ENVIRONMENTAL MICROBIOLOGY

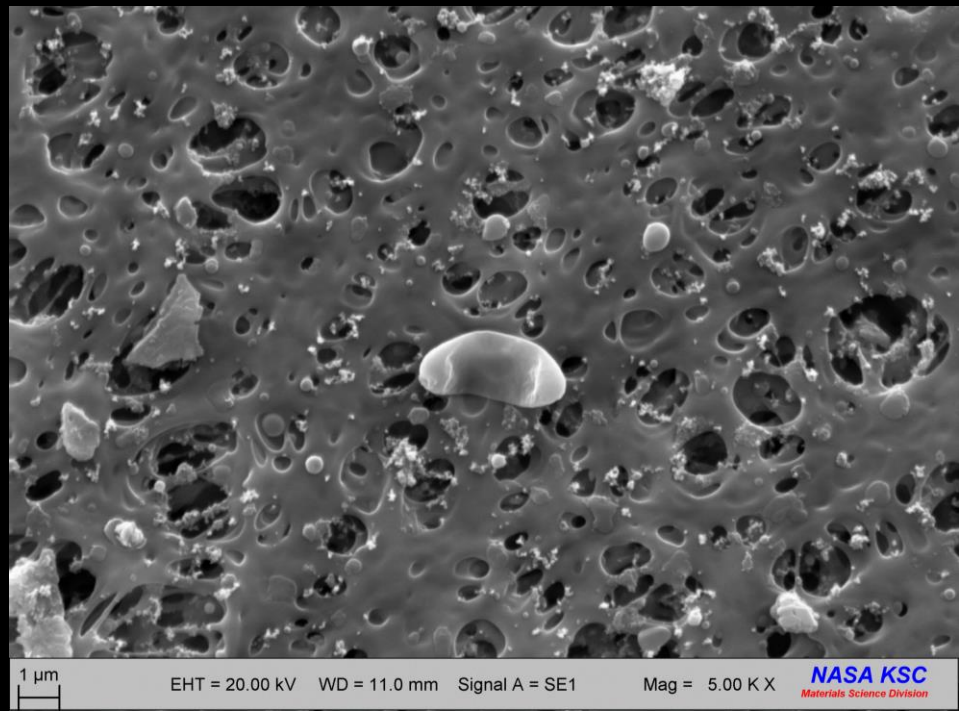
Free Tropospheric Transport of Microorganisms from Asia to North America

David J. Smith · Daniel A. Jaffe · Michele N. Birmele · Dale W. Griffin · Andrew C. Schuerger · Jonathan Hee · Michael S. Roberts




10 µm
EHT = 20.00 kV
WD = 11.0 mm
Signal A = SE1
Mag = 1.00 K X
NASA KSC
Materials Science Division


1 µm
EHT = 20.00 kV
WD = 11.0 mm
Signal A = SE1
Mag = 5.00 K X
NASA KSC
Materials Science Division

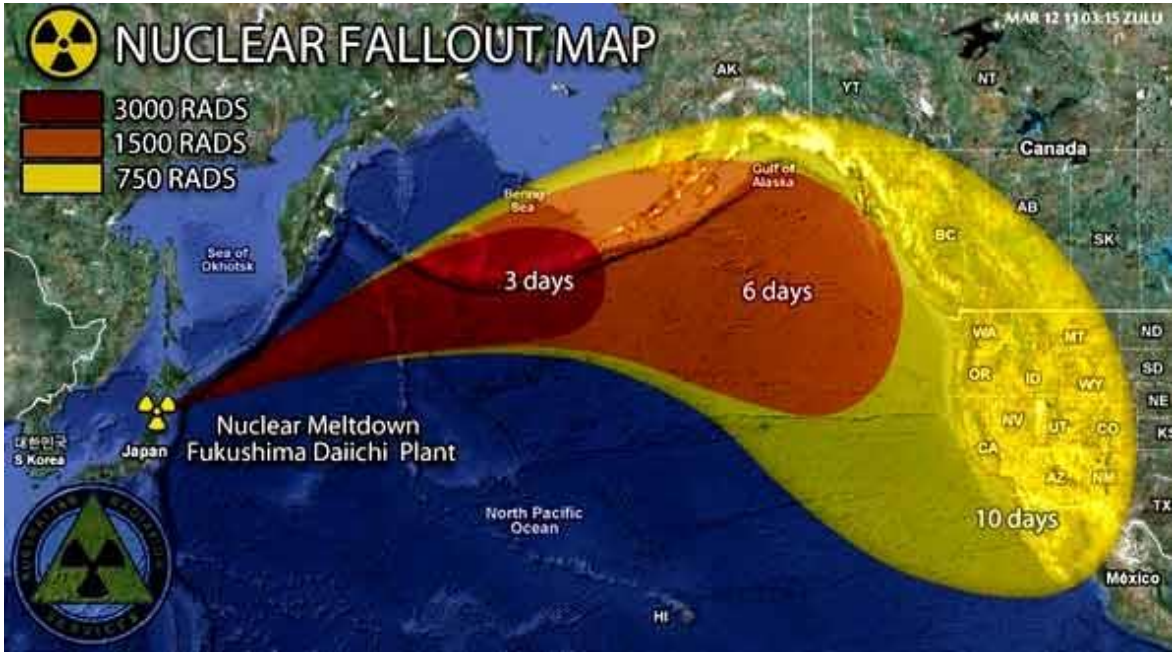

1 µm
EHT = 20.00 kV
WD = 11.0 mm
Signal A = SE1
Mag = 5.00 K X
NASA KSC
Materials Science Division

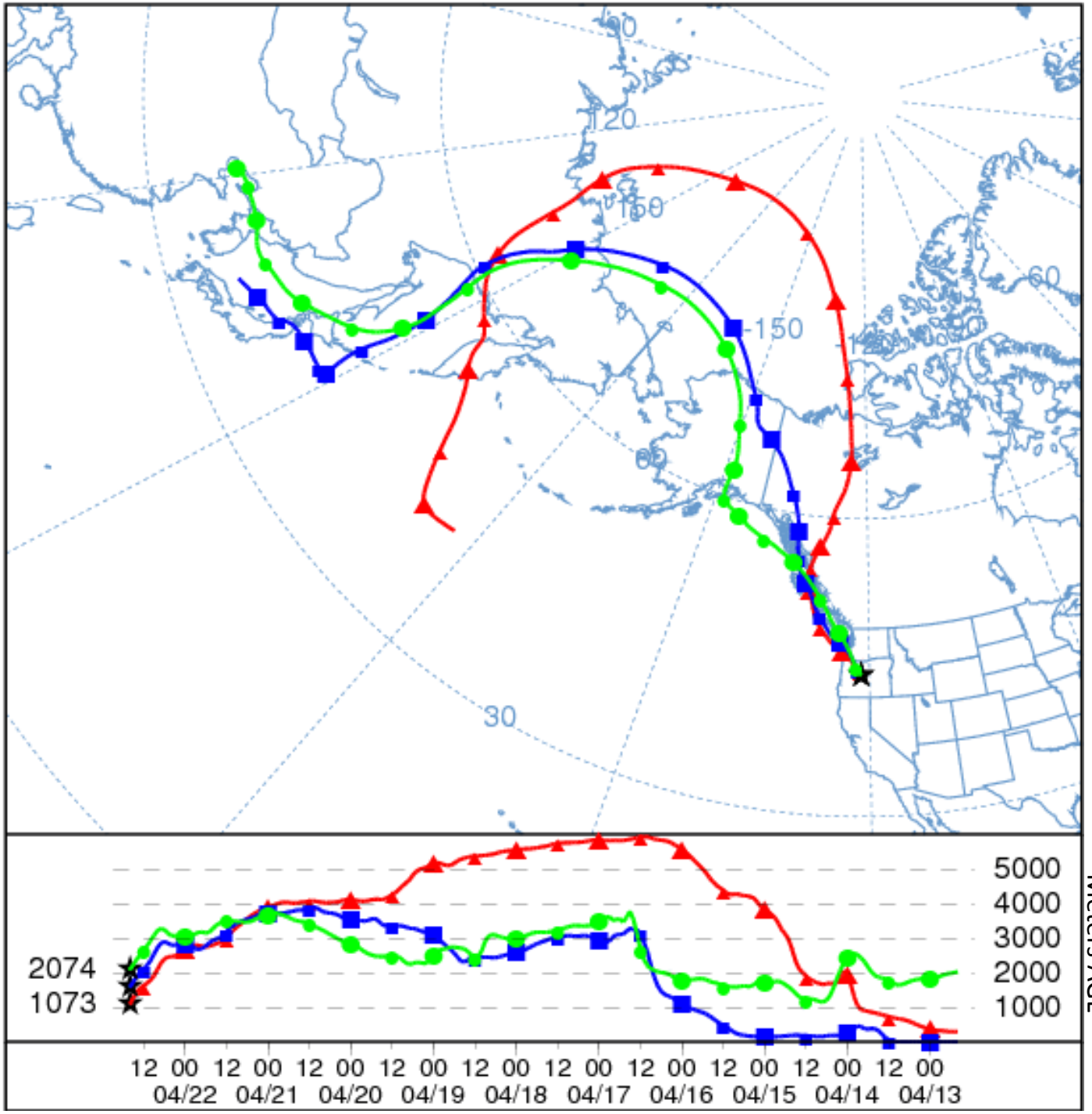
Color	Phylum
	Proteobacteria
	Actinobacteria
	Firmicutes
	Bacteroidetes
	Acidobacteria
	Chloroflexi
	Armatimonadetes
	Other

Heatmap Legend	
	0.68
	0.79
	0.90
	1.00
	1.24
	1.48
	1.72

Asian Long Range Transport independently derived from:

1. **Sampling location, season** (prevailing free tropospheric westerlies; subsiding oceanic fronts)
2. **Meteorological data** (NOAA HYSPLIT)
3. **Satellite data** (NAAPS model)
4. **Aged aerosols** (enhancements & correlations)
5. **Plume chemistry** (composition & correlations)
6. **Microbial biogeography** (species)




90
120
150
-150
60
30
2074
1073
5000
4000
3000
2000
1000
Meters AGL
12 00 12 00 12 00 12 00 12 00 12 00 12 00 12 00 12 00 12 00 12 00
04/22 04/21 04/20 04/19 04/18 04/17 04/16 04/15 04/14 04/13

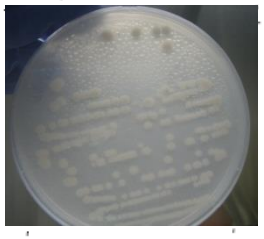
Aerobiologia (2010) 26:35–46
DOI 10.1007/s10453-009-9141-7

ORIGINAL PAPER

Stratospheric microbiology at 20 km over the Pacific Ocean

David J. Smith · Dale W. Griffin · Andrew C. Schuerger

Bacillus endophyticus, *Bacillus subtilis*, *Bacillus* sp.



class *Eurotiomycetes* and *Penicillium* sp.

Global atmospheric transport of microbes happens

Global atmospheric transport of microbes is very likely

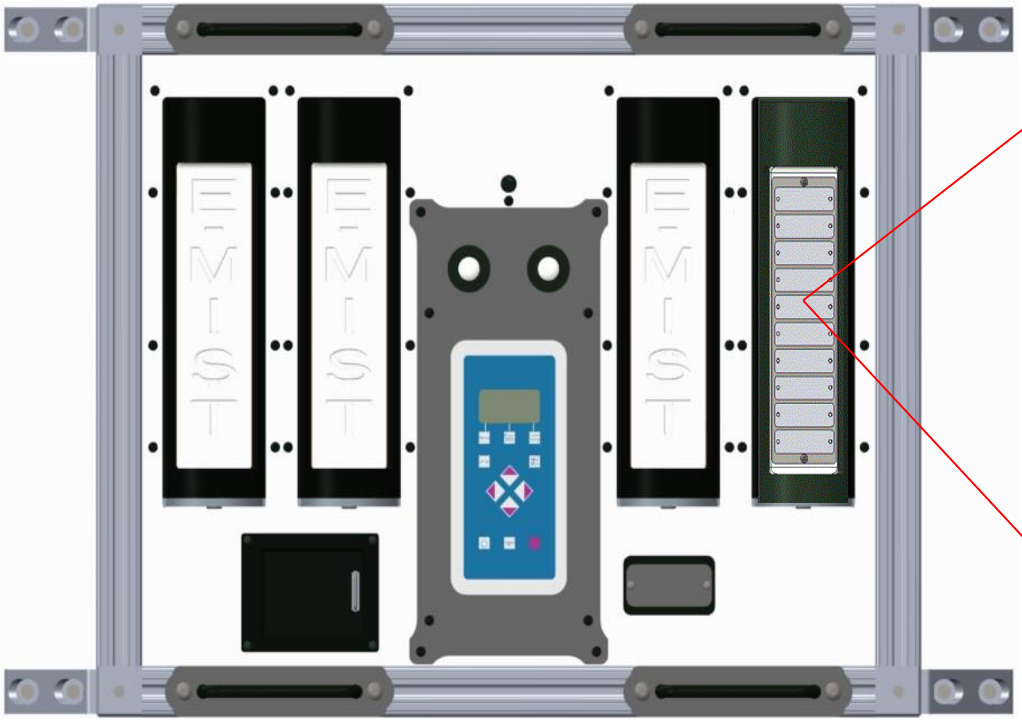
What can we do about it on Mars? Not sure, but we can improve our understanding of atmospheric survival

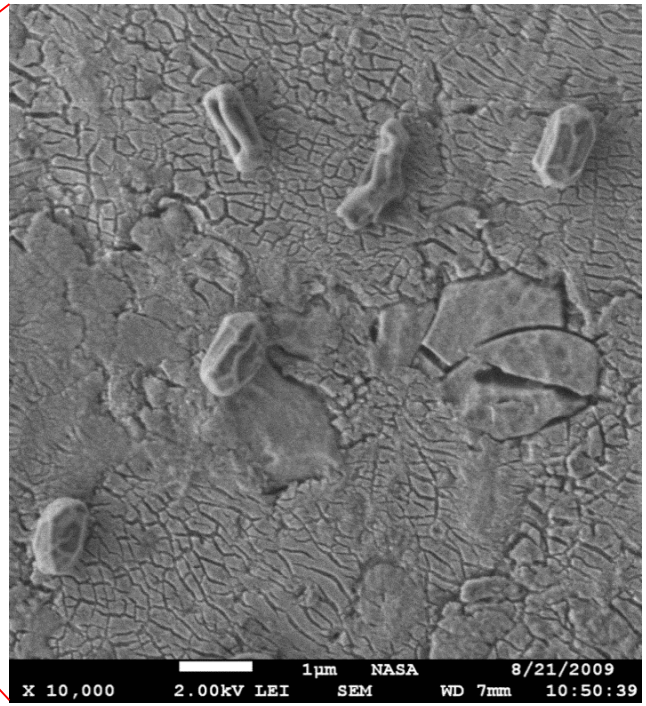
NASA BALLOON PROGRAM

http://www.csbf.nasa.gov/

EXPOSING MICROORGANISMS IN THE STRATOSPHERE (E-MIST)

Earth's stratosphere features environmental conditions similar to the surface of Mars: extreme dryness, cold, radiation, and ultralow pressure. Our payload (E-MIST) has 4 independently rotating skewers that will hold known-quantities of spore-forming bacteria that were previously isolated from spacecraft assembly facilities. We know these microbes are traveling to Mars on NASA spacecraft; will they survive once reaching the Red Planet?





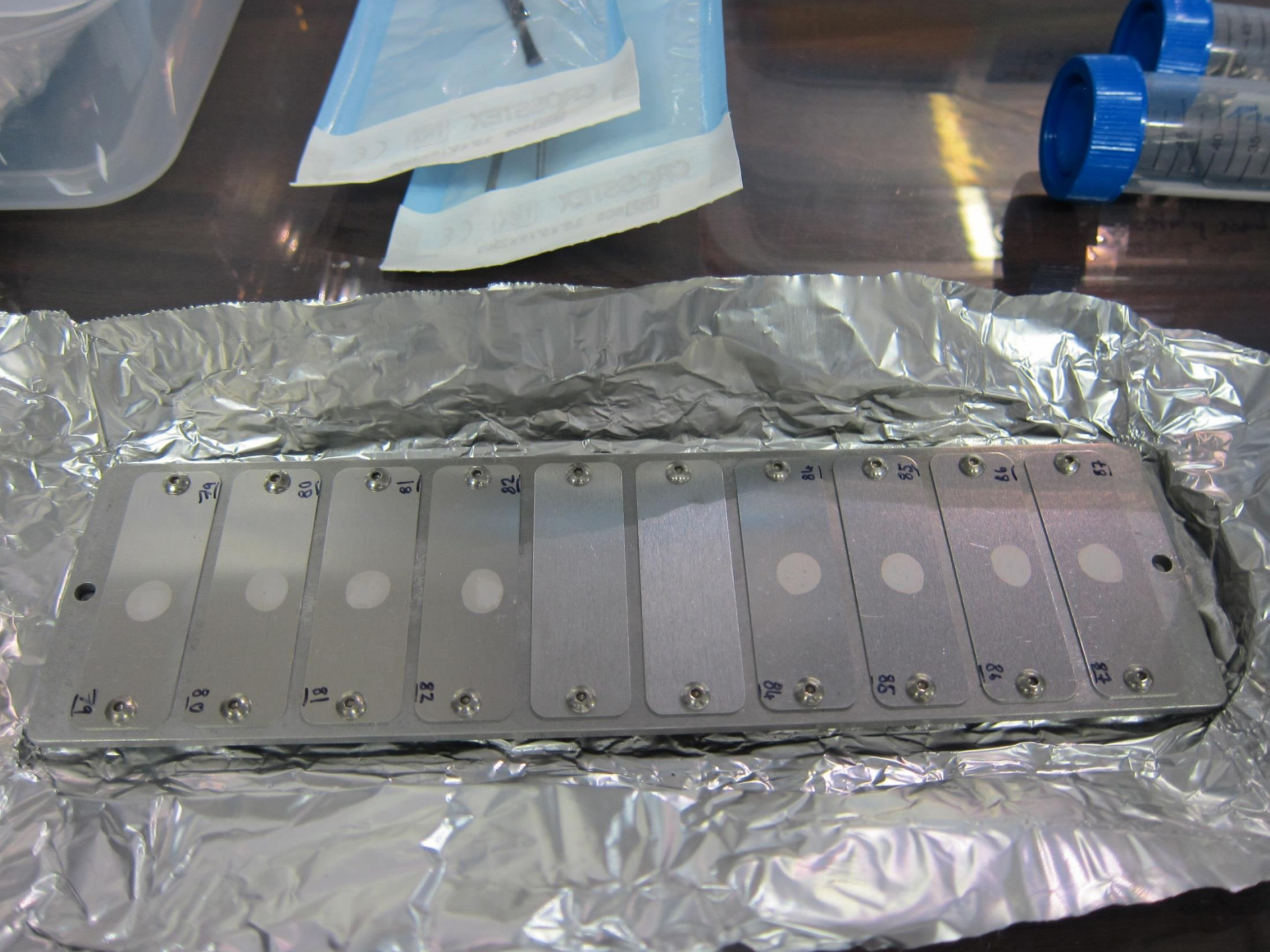
KSC ENGINEERING

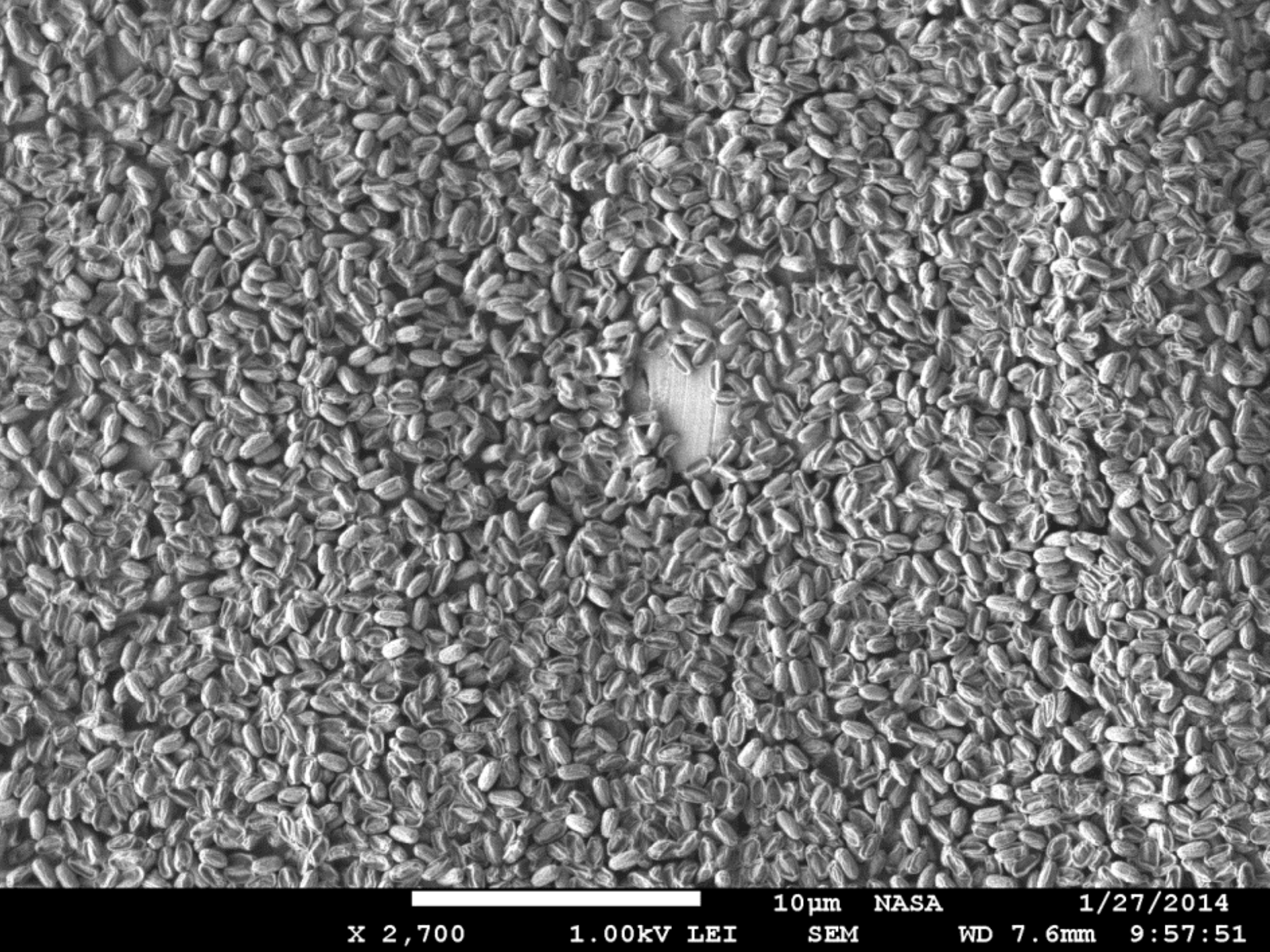
COLUMBIA SCIENTIFIC BALLOON FACILITY

NASA KENNEDY SPACE CENTER PDL PROTOTYPE DEVELOPMENT LABORATORY

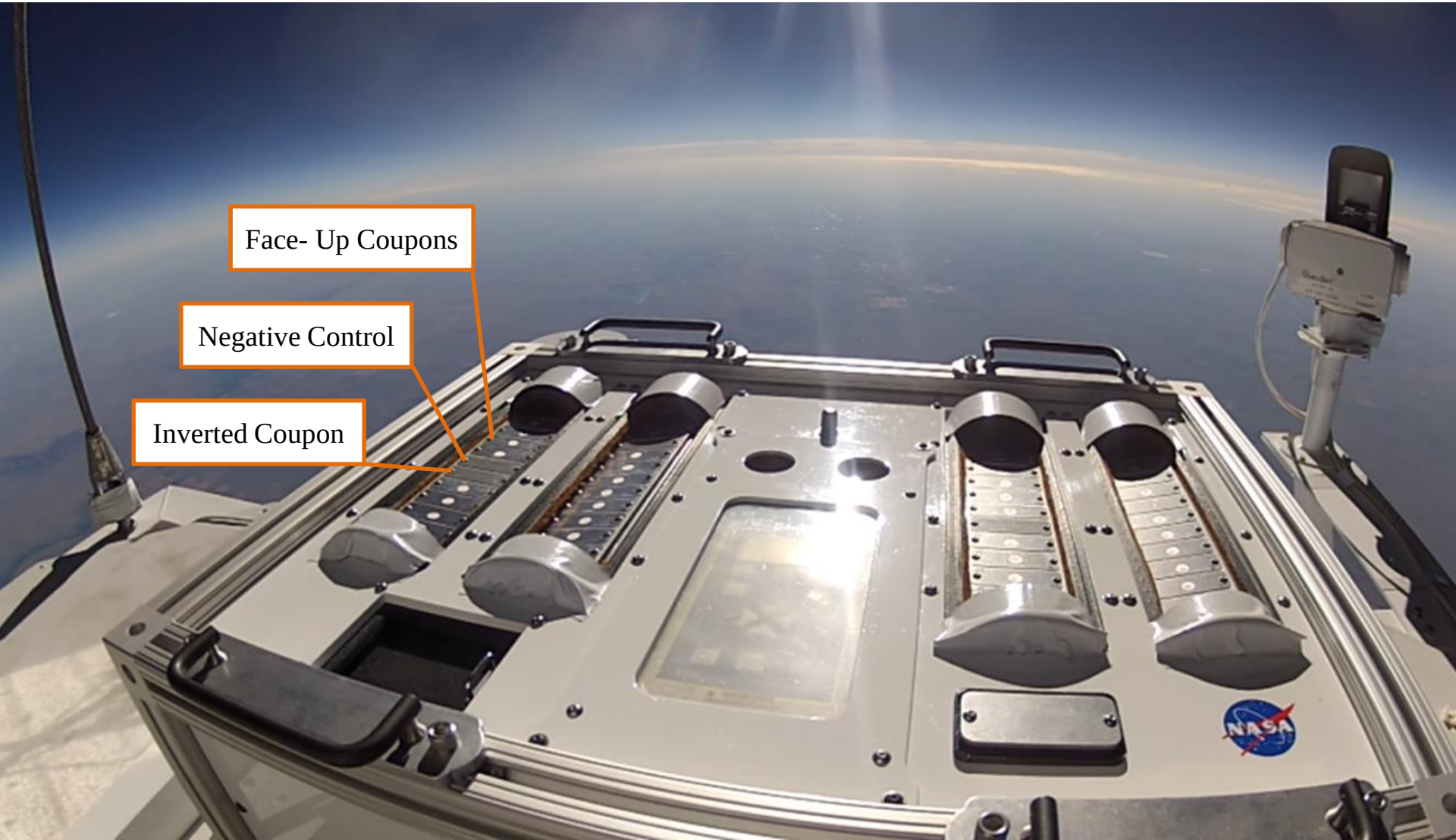
Rocket University RU Ready

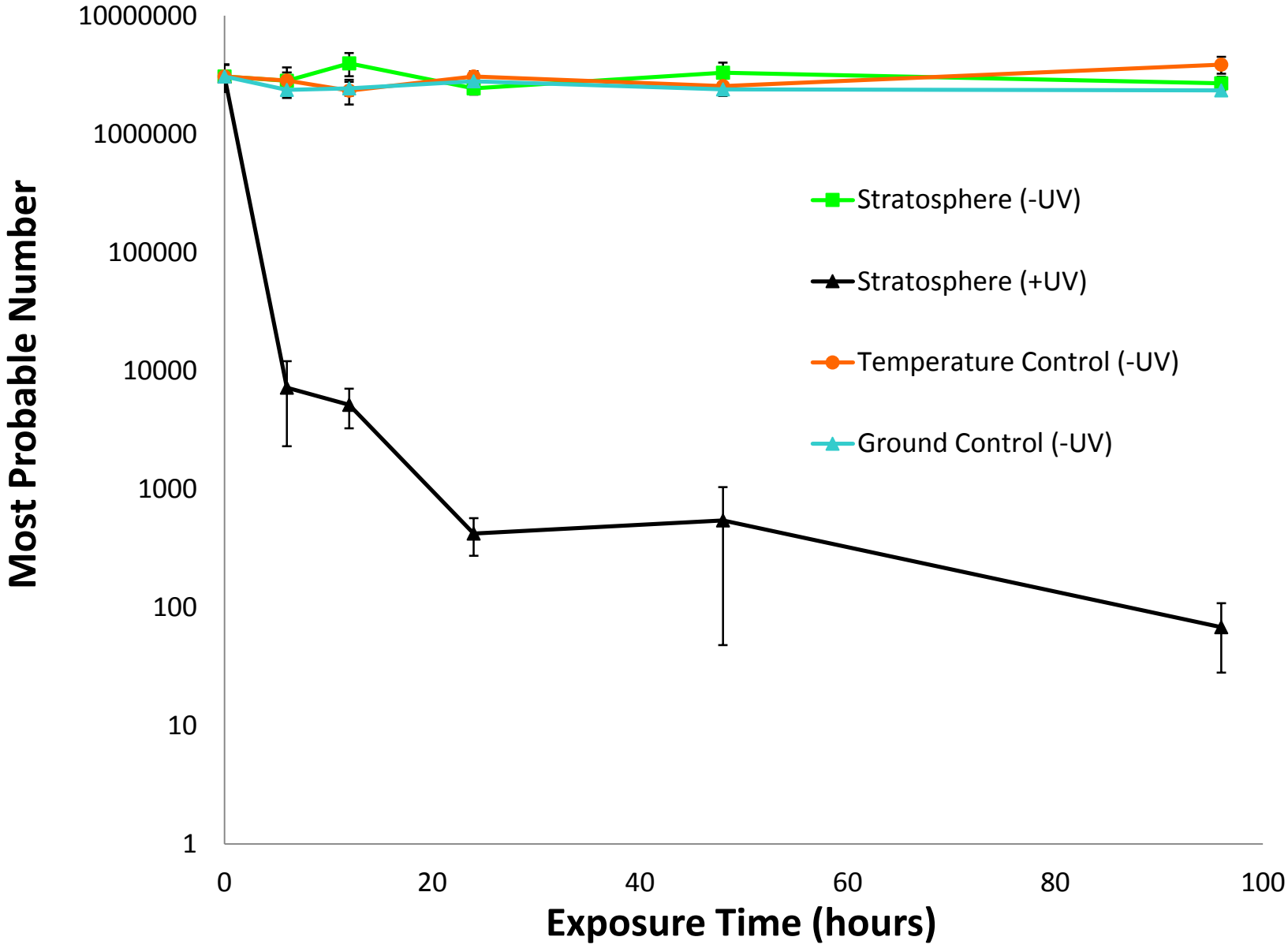

MIST
MIST
MIST
MIST
SOLAR




10µm NASA 1/27/2014
X 2,700 1.00kV LEI SEM WD 7.6mm 9:57:51

We can (and should) expose anything and everything that has been isolated from a spacecraft environment.




10000000
1000000
100000
10000
1000
100
10
1
Most Probable Number
0
20
40
60
80
100
Exposure Time (hours)
Stratosphere (-UV)
Stratosphere (+UV)
Temperature Control (-UV)
Ground Control (-UV)

E-MIST TEAM

Principal Investigator:	David J. Smith
Project Manager/ SE Lead:	Nicole Dawkins
Design and Fabrication:	Prital Thakrar
Avionics:	Anthony Bharrat
	Brad Shea
	Karl Stolleis
	Mike Lane
	Leandro James
Structures and Analysis:	Susan Danley
	Evan Williams
	Jackson Kinney
	Pierce Louderback
	Dan Ciarlariello
	Dean Lewis
	Ryan Honour
Logistics:	Susan Kasica
	Tim Prilo
Advisors:	Adam Dokos
	Steve Sullivan
	Teresa Kinney
	Chris Iannello
	Kelvin Ruiz
	Pat Meyer